porosity in the range of about 70% to 98% within said polymeric support,

at least one ion exchange resin filling said microstructure such that said composite membrane is air impermeable, said composite membrane having a thickness of at most 0.8 mils and an ionic conductance rate of at least 5.1 μmhos/min.

100 ~~101~~. The composite membrane of claim ~~100~~ 99, wherein said polymeric support is a polyolefin.

101 ~~102~~. The composite membrane of claim ~~100~~ 99, wherein said polymeric support is a fluorinated polymer.

102 ~~103~~. The composite membrane of claim ~~100~~ 99, wherein said polymeric support is a chlorinated polymer.

103 ~~104~~. The composite membrane of claim ~~102~~ 101, wherein said fluorinated polymer is polytetrafluoroethylene.

104 ~~105~~. The composite membrane of claim ~~104~~ 103, wherein said polytetrafluoroethylene is expanded polytetrafluoroethylene.

105 ~~106~~. The composite membrane of claim ~~100~~ 99, wherein said polymeric support is a polyamide.

106 ~~107~~. The composite membrane of claim ~~100~~ 99, wherein said polymeric support is a polycarbonate.

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107 ~~108~~. The composite membrane of claim ~~102~~ 101, wherein said microstructure includes nodes interconnected with fibrils.

106 ~~109~~. The composite membrane of claim ~~104~~ 103, wherein said microstructure includes nodes interconnected with fibrils.

109 ~~110~~. The composite membrane of claim ~~100~~ 99, wherein the thickness of said composite membrane is in the range of between 0.06 and 0.8 mils.

110 ~~111~~. The composite membrane of claim ~~100~~ 99, wherein the thickness of said composite membrane is in the range of between about 0.5 and 0.8 mils.

111 ~~112~~. The composite membrane of claim ~~100~~ 99, wherein the thickness of said composite membrane is at most 0.5 mils.

112 ~~113~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a mixture of ion exchange resins.

113 ~~114~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a perfluorinated sulfonic acid resin.

114 ~~115~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a perfluorinated carboxylic acid resin.

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115 ~~116~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a polyvinyl alcohol.

116 ~~117~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a divinyl benzene resin.

117 ~~118~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin comprises a styrene-based polymer.

118 ~~119~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin further comprises metal salts with or without a polymer.

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119 ~~120~~. The composite membrane of claim ~~113~~ 112, wherein said mixture of ion exchange resins includes at least two of a perfluorinated sulfonic acid resin, a perfluorinated carboxylic acid resin, a polyvinyl alcohol resin, a divinyl benzene resin or a styrene-based polymer.

120 ~~121~~. The composite membrane of claim ~~100~~ 99, wherein said at least one ion exchange resin is a perfluorosulfonic acid/tetrafluoroethylene copolymer resin.

121 ~~122~~. The composite membrane of claim ~~100~~ 99, further comprising a reinforcement backing bonded to a side thereof.

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122 ~~123~~. An integral substantially air occlusive integral composite membrane having a polymeric support with a microstructure of pores, said microstructure filled with an ion exchange resin, said composite membrane has an ionic conductance rate of at least 5.1 μmhos/min, said composite membrane prepared by,

(a) providing a polymeric support having a microstructure of micropores;

(b) sequentially applying an ion exchange resin solution to each major surface of said polymeric support; and

(c) repeating step (b) until said micropores are sufficiently filled with ion exchange resin to form an air occlusive integral composite membrane.

123 ~~124~~. The composite membrane of claim 122 ~~123~~, wherein said step (b) further includes,

(b1) drying said support after each application of ion exchange resin solution to remove solvent from said solution.

124 ~~125~~. The composite membrane of claim 122 ~~123~~, wherein said step (b) includes at least three successive applications of said ion exchange resin solution.

125 ~~126~~. The composite membrane of claim 122 ~~123~~, wherein said step (b) includes at least four successive applications of said ion exchange resin solution.

126 ~~127~~. The composite membrane of claim 122 ~~123~~, wherein said step (b) includes at least three

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successive applications of said ion exchange resin solution, each followed by a drying step.

127 ~~128~~. The composite membrane of claim ~~123~~ 122, wherein said step (b) includes at least four successive applications of said ion exchange resin solution, each followed by a drying step.

128 ~~129~~. The composite membrane of claim ~~123~~ 122, wherein said support comprises a polyolefin.

129 ~~130~~. The composite membrane of claim ~~123~~ 122, wherein said support comprises a fluorinated polymer.

130 ~~131~~. The composite membrane of claim ~~123~~ 122, wherein said support comprises a chlorinated polymer.

131 ~~132~~. The composite membrane of claim ~~130~~ 129, wherein said fluorinated polymer is polytetrafluoroethylene.

132 ~~133~~. The composite membrane of claim ~~132~~ 131, wherein said polytetrafluoroethylene is expanded polytetrafluoroethylene.

133 ~~134~~. The composite membrane of claim ~~123~~ 122, wherein said support comprises a polyamide.

134 ~~135~~. The composite membrane of claim ~~123~~ 122, wherein said support comprises a polycarbonate.

135 ~~136~~. The composite membrane of claim ~~130~~ 129, where said microstructure includes nodes

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interconnected with fibrils.

136 ~~137~~. The composite membrane of claim 122 ~~123~~, having a thickness in the range between 0.06 and 0.8 mils.

137 ~~138~~. The composite membrane of claim 136 ~~137~~, having a thickness in the range of between about 0.5 and at most 0.8 mils.

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138 ~~139~~. The composite membrane of claim 136 ~~137~~, having a thickness of at most about 0.5 mils.

139 ~~140~~. The composite membrane of claim 122 ~~123~~, wherein said ion exchange resin is a mixture of resins.

140 ~~141~~. The composite membrane of claim 122 ~~123~~, wherein said ion exchange resin is a perfluorinated sulfonic acid resin.

141 ~~142~~. The composite membrane of claim 126 ~~127~~, wherein said drying is conducted at about room temperature.

142 ~~143~~. The composite membrane of claim 122 ~~123~~, wherein said ion exchange resin solution is applied in the presence of a surfactant.

143 ~~144~~. The composite membrane of claim 123 ~~124~~, wherein said ion exchange resin solution is

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applied in the presence of a surfactant.

144 ~~145~~. A method of preparing a substantially air occlusive integral composite comprising:

(a) providing a polymeric support having a microstructure of micropores;

(b) sequentially applying an ion exchange resin solution to each major surface of said polymeric support; and

(c) repeating step (b) until said micropores are sufficiently filled with ion exchange resin to form an air occlusive integral composite membrane which has an ionic conductance rate of at least 5.1 μmhos/min.

145 ~~146~~. The method of claim 144, wherein said step (b) includes at least three successive applications of said ion exchange resin solution.

146 ~~147~~. The method of claim 144, wherein said step (b) includes at least four successive applications of said ion exchange resin solution.

147 ~~148~~. The method of claim 144, wherein said step (b) includes at least two successive applications of said ion exchange resin solution, each followed by a drying step.

148 ~~149~~. The method of claim 144, wherein said step (b) includes at least three successive applications of said ion exchange resin solution, each followed by a drying step.

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149 ~~150~~. The method of claim 144 ~~145~~, wherein said providing step (a) comprises providing as said polymeric support a polyolefin support.

150 ~~151~~. The method of claim 144 ~~145~~, wherein said providing step (a) comprises providing as said polymeric support a fluorinated polymer support.

151 ~~152~~. The method of claim 144 ~~145~~, wherein said providing step (a) comprises providing as said polymeric support a chlorinated polymer support.

B1 Cont 152 ~~153~~. The method of claim 150 ~~151~~, wherein said fluorinated polymer is polytetrafluoroethylene.

153 ~~154~~. The method of claim 152 ~~153~~, wherein said polytetrafluoroethylene is expanded polytetrafluoroethylene.

154 ~~155~~. The method of claim 144 ~~145~~, wherein said providing step (a) comprises providing as said polymeric support a polyamide.

155 ~~156~~. The method of claim 144 ~~145~~, wherein said providing step (a) comprises providing as said polymeric support a polycarbonate support.

156 ~~157~~. The method of claim 144 ~~145~~, where said microstructure includes nodes interconnected with fibrils.

157 ~~158~~. The method of claim ~~145~~ 144, wherein said composite membrane has a thickness within the range of 0.06 to 0.8 mils.

158 ~~159~~. The method of claim ~~145~~ 144, wherein said composite membrane has a thickness within the range of 0.5 to 0.8 mils.

159 ~~160~~. The method of claim ~~145~~ 144, wherein said composite membrane has a thickness of at most 0.5 mils.

160 ~~161~~. The method of claim ~~145~~ 144, wherein said ion exchange resin is a mixture of resins.

161 ~~162~~. The method of claim ~~145~~ 144, wherein said ion exchange resin is a perfluorinated sulfonic acid resin.

162 ~~163~~. The method of claim ~~146~~ 145, wherein said at least three successive applications of said ion exchange solution include alternate applications of said resin solution to a first side of said support and then to a second side of said support.

163 ~~164~~. A fuel cell including an ultra-thin, air impermeable integral composite membrane; said composite membrane comprising:

a polymeric support having a microstructure of micropores, said microstructure defining a porosity in the range of about 70% to 95% within said polymeric support,

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at least one ion exchange resin filling said microstructure such that said composite membrane is air impermeable, said composite membrane having a thickness of at most 0.8 mils.

164 ~~165~~. The fuel cell of claim 163, wherein said polymeric support is a fluorinated polymer.

165 ~~166~~. The fuel cell of claim 164, wherein said fluorinated polymer is polytetrafluoroethylene.

166 ~~167~~. The fuel cell of claim 163, wherein said microstructure includes from nodes interconnected with fibrils.

167 ~~168~~. The fuel cell of claim 163, wherein said composite membrane has a thickness in the range of between 0.06 and at most 0.8 mils.

168 ~~169~~. The fuel cell of claim 167, wherein said composite membrane has a thickness of at most 0.5 mils.

169 ~~170~~. The fuel cell of claim 167, wherein said at least one ion exchange resin comprises a mixture of ion exchange resins.

170 ~~171~~. The fuel cell of claim 163, wherein said at least one ion exchange resin comprises a perfluorinated sulfonic acid resin.

171 ~~172~~. The method according to claim ~~145~~ 144, wherein step (b) is performed in the presence of a surfactant.

172 ~~173~~. The composite membrane of claim ~~110~~ 109, wherein the thickness of said composite membrane is at most 0.4 mils.

173 ~~174~~. The composite membrane of claim ~~110~~ 109, wherein the thickness of said composite membrane is at most 0.3 mils.

174 ~~175~~. The composite membrane of claim ~~110~~ 109, wherein the thickness of said composite membrane is at most 0.2 mils.

175 ~~176~~. The composite membrane of claim ~~110~~ 109, wherein the thickness of said composite membrane is at most 0.1 mils.

176 ~~177~~. The composite membrane of claim ~~137~~ 136, wherein the thickness of said composite membrane is at most 0.4 mils.

177 ~~178~~. The composite membrane of claim ~~137~~ 136, wherein the thickness of said composite membrane is at most 0.3 mils.

178 ~~179~~. The composite membrane of claim ~~137~~ 136, wherein the thickness of said composite membrane is at most 0.2 mils.

179 180. The composite membrane of claim 136, wherein the thickness of said composite membrane is at most 0.1 mils.

180 181. The composite membrane of claim 144, wherein said step (b) further includes,

(b1) drying said support after each application of ion exchange resin solution to remove solvent from said solution.

181 182. The composite membrane of claim 157, wherein the thickness of said composite membrane is at most 0.4 mils.

182 183. The composite membrane of claim 157, wherein the thickness of said composite membrane is at most 0.3 mils.

183 184. The composite membrane of claim 157, wherein the thickness of said composite membrane is at most 0.2 mils.

184 185. The composite membrane of claim 157, wherein the thickness of said composite membrane is at most 0.1 mils.

185 186. The composite membrane of claim 167, wherein the thickness of said composite membrane is at most 0.4 mils.